INHIBITION AND EXCITATION IN THE CENTRAL NERVOUS SYSTEM : A PRELIMINARY NOTE.*

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I.—INEQUALITY OF INHIBITION AND EXCITATION GIVEN BY THE SAME REFLEX STIMULUS.

IN such an act as the flexion-reflex, one group of muscles (flexors) contracts, and the antagonistic group (extensors) relaxes—if they have previously been in a state of tonic contraction. Sherrington ascribed this phenomenon to the reciprocal innervation of antagonistic groups of muscles. One single stimulus *excites* an increase of discharge in the flexor motor neurones, and simultaneously *inhibits* any discharge present in the extensor motor neurones. The same stimulus produces central excitation and central inhibition, but in antagonistic motor neurones.

The question whether the excitation is equal to the inhibition (that is, whether the excitation produced in one group of motor neurones is equal to that which the inhibition can just overcome in the antagonistic group) is a fundamental one. Sherrington¹ and other workers have assumed that this equality obtains. If two *antagonistic* reflexes (flexion and extension) are pitted against one another to give a compound reflex, the resultant is intermediate between the two—Sherrington's 'algebraic summation' of flexion and extension in the compound reaction. Each group of motor neurones is then acted on by both excitation and inhibition—by the excitation produced by one stimulus, and the inhibition produced by the other.

Let us assume that the excitation equals the inhibition given by each of the stimuli. The excitation of one stimulus is met by the inhibition of the other in the same motor neurone (or group of motor neurones). Thus, where *that* excitation and inhibition are equal, there must also be equality between the inhibition and excitation in the *other* group of motor neurones. (Things equal to the same thing are equal to one another.) In other words, where the strengths of stimuli are such as to give exact suppression of excitation in one group of neurones, they must also give it in the other. At all

* From the Physiology Institute, Cardiff.

other strengths of stimuli, the excitation will overcome the inhibition in one group of motor neurones, and the inhibition will more than suppress the excitation in the other.

Thus simultaneous discharge should not be seen in the two antagonistic groups of motor neurones during a compound reflex if exact equality occurs between the inhibition and excitation given by the same reflex stimulus.

But simultaneous contraction may occur in both sets of antagonistic muscles during a compound reflex. Therefore simultaneous discharge may occur in the two antagonistic groups of motor neurones. Therefore the excitation and inhibition given by the same stimulus are then unequal. The facts of the case necessitate that the inhibition shall then be less than the excitation at any rate in the case of one stimulus. The invocation of an additional 'tonic' discharge does not alter the argument.

II.—THE VARIATION OF INHIBITION.

The value of inhibition may be measured by its effect in reducing the size of an antagonistic excitation—by the relaxation of an antagonistic contraction. (Thus a flexion-reflex inhibition reduces the extensor contraction against which it acts.)

My measurements show that the value of inhibition is relatively less in the extension-reflex than in the flexion-reflex where double contraction occurs in compound reflexes. The ratio of inhibition to excitation is less for extension-producing stimuli—they are the milder of the two. This relationship is also shown by the fact (Sherrington) that a maximal flexion completely overcomes a maximal extension.

This is one aspect of the variation of inhibition—it is relatively less in extension than in flexion. Another aspect is the variation in either case with change of intensity of stimulus.

The inhibition given by a series of reflex stimuli is more intense when the stimuli are more intense, and less intense when they are mild. The inhibition which accompanies great flexion is greater than that which accompanies slight flexion.

But a third aspect is presented by the possibility that the *ratio* of inhibition to excitation may change while both of them increase or decrease in absolute value. This variation has not yet been described.

If an extension of fixed intensity is pitted against different intensities of flexion, it should give the same amount of relaxation in each case—provided the inhibition in the constant extension is itself constant.

As a matter of fact the relaxation is less where the flexion is

greater. Therefore the relation (ratio) of the inhibition to the excitation given in extension varies with the intensity of the flexion against which it is compounded. This variation may be expressed by saying that, in the extension-reflex, the ratio I : E (inhibition to excitation) varies inversely with the excitation against which the inhibition is pitted (or, more widely, inversely with the intensity of the antagonistic flexion-reflex).

If different intensities of flexion are pitted against a fixed extension, relaxation of different degrees occurs in the extensor muscle. This measures the inhibition in the flexion-reflexes. It should be a fixed proportion of the contractions in the simple flexion-reflexes which are used in the compound reflex, if the relation between inhibition and excitation is the same at all intensities of flexion.

It is found in actual experiment that the extensor relaxation is proportionally greater the more intense the flexion is. Therefore the relation between inhibition and excitation varies with the intensity of the flexion-reflex. This is expressed by saying that the ratio I : E for the flexion-reflex varies directly with the intensity of excitation in the flexion-reflex itself.

Therefore inhibition does not remain the same ratio of excitation at all intensities of flexion and of extension. The ratio varies in the case of flexion with the intensity of flexion itself; and in the case of extension it varies inversely with the intensity of the flexion against which it is pitted in a compound reflex.

This variation is perhaps of fundamental significance.

REFERENCE.

- ¹ SHERRINGTON, *Proc. Roy. Soc., B*, 1913, lxxxvi, 219.